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13. ABSTRACT *(Maximum 200 words)*

A new approach was investigated for achieving lighter spur gears with longer service life by altering the stress distribution in the gear by introducing hollow and filled holes through the gear face parallel to the shaft axis. The study was conducted using two-dimensional I-DEAS and ANSYS finite element models. The intent was to strategically redistribute the stresses to reduce the critical stress at the root fillet of the tooth. Stresses at the contact area were also monitored. Three strategies were investigated: 1) various hollow hole patterns; 2) press/shrink-fit plugs in the holes to introduce a compressive preload; 3) a high modulus of elasticity insert in a gear blank of low modulus material. The hollow hole patterns reduced the fillet stress up to 5% while increasing contact stress and deflection slightly. Press/shrink-fit plugs which imparted an initial compressive stress at the fillet reduced the stress only slightly more than holes alone. High modulus inserts in a low modulus gear gave the best results, achieving up to 50% stress reduction at the fillet while also reducing the contact stress and tooth deflection.

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A NEW APPROACH FOR OPTIMUM GEAR DESIGN

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A NEW APPROACH FOR OPTIMUM GEAR DESIGN
(ARO Agreement No. DAAH04-93-2-0016)

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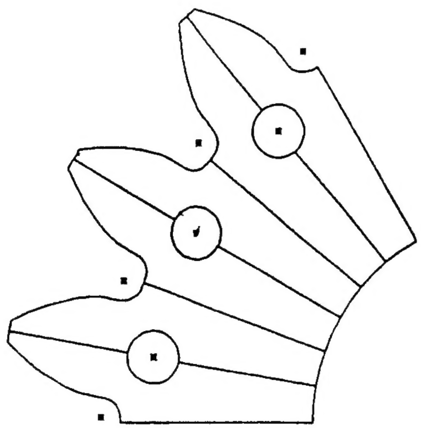
STATEMENT OF THE PROBLEM

The objective of the research was to investigate a new approach for achieving lighter spur gears with longer service life. It is well known that holes or other geometric discontinuities can alter the stress distribution in a component. Furthermore, since fatigue life is very susceptible to stress concentration, it can be greatly increased by small reductions in stress in the area of highest stress concentration. These two principals were applied to spur gears by introducing hollow or filled holes, through the gear face parallel to the shaft axis, to improve the gear fatigue life. The intent was to strategically redistribute the stresses to reduce the critical stress at the root fillet of the tooth. Stresses at the contact area were also monitored.

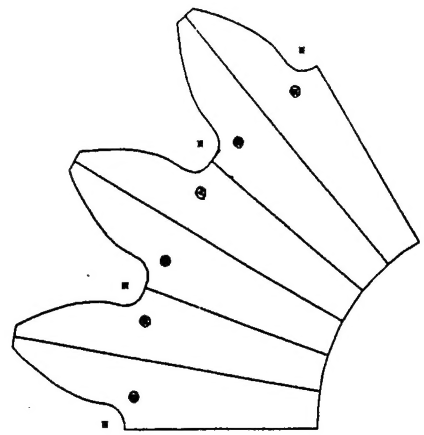
Using a two-dimensional finite element model, three strategies to reduce the critical stresses were investigated. The first introduced various hole patterns through the gear face parallel to the axis of the shaft. The configurations were varied with respect to size, location and shape of the holes. The second strategy considered press/shrink-fit plugs in the holes to impart an initial compressive preload at the fillet. The third method incorporated a high modulus of elasticity insert in a gear blank of low modulus material. In this approach, the low modulus material at the stress concentration deforms within the elastic range shifting some of the stress to the high modulus material at a position removed from the stress concentration. Examples of the type of hole and insert patterns investigated are shown in the figures on page 2.

SUMMARY OF RESULTS

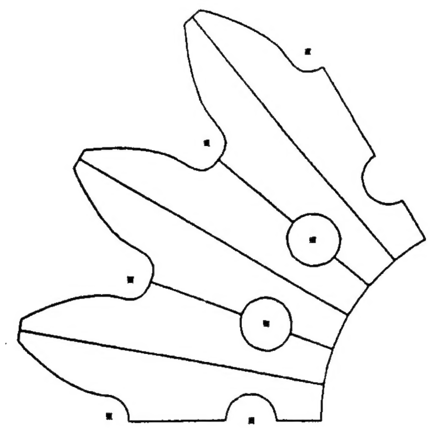
Hole patterns reduced the fillet stress up to 5% while increasing contact stress and deflection slightly. Press/shrink-fit plugs which imparted an initial compressive stress at the fillet reduced the stress only slightly more than holes alone. High modulus inserts in a low modulus gear gave the best results, achieving up to 50% stress reduction at the fillet while also reducing the contact stress and tooth deflection. The results of the study show promise for the proposed strategies. Additional work using optimization techniques to arrive at the most effective configurations should produce further stress reduction.



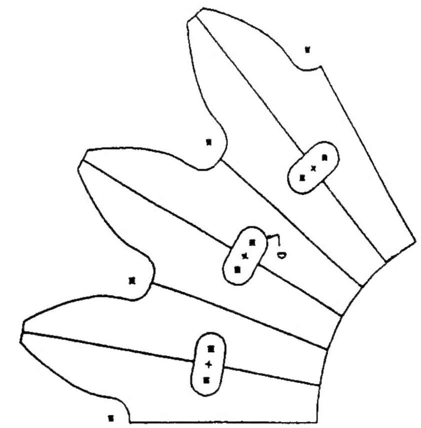
Circular Hole
at Tooth Center Line



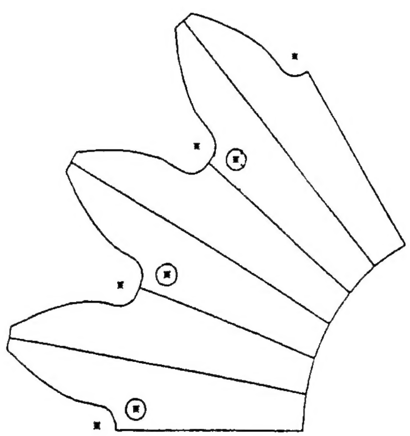
Two Circular Holes
at Tooth Boundary



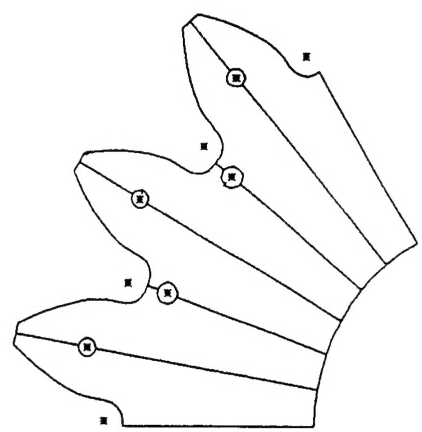
Circular Hole
at Root Center Line



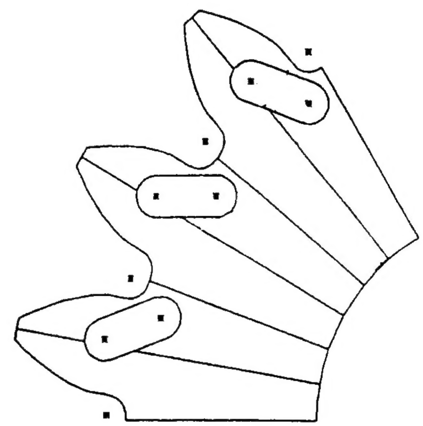
Slot at Tooth
Center Line



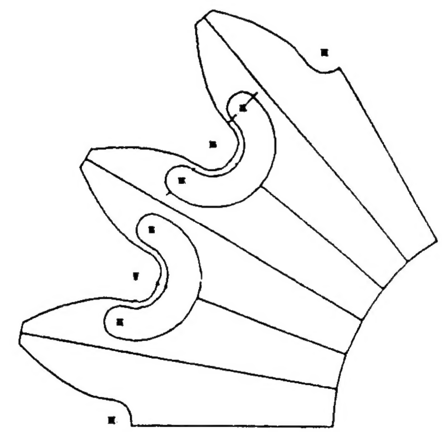
Pressurized Circular Hole
Near Tooth Side



Multiple Pressurized
Holes



Two-Material Gear
(Straight Slot Insert)



Two-Material Gear
(Semicircular Insert)

A New Approach for Optimum Gear Design

HOLE AND INSERT PATTERNS INVESTIGATED

LIST OF ALL PUBLICATIONS AND TECHNICAL REPORTS

Masoud, Samer, **"Improving Spur-Gear Performance,"** Ph.D., dissertation; University of Cincinnati; Division of Advanced Studies; Department of Mechanical, Industrial and Nuclear Engineering; College of Engineering; Cincinnati, Ohio, 1994.

Masoud, S. (1), M. Brown (1), W. Grissom (2) and J. Sutliff (1), **"Strengthening Spur Gears by Altering Stress Distribution,"** (1) Dept. of Mechanical, Industrial and Nuclear Engineering, University of Cincinnati, (2) Department of Manufacturing Engineering, Central State University, manuscript to be submitted for publication, 1995.

REPORT OF INVENTIONS

No disclosures or patent applications filed to date.

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